STATUS OF REDUCED ENRICHMENT PROGRAM FOR RESEARCH REACTORS IN JAPAN

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ABSTRACT

The reduced enrichment programs for the JRR-3M, JRR-4 and JMTR of Japan Atomic Energy Research Institute (JAERI) have been completed. The KUR of Kyoto University Research Reactor Institute (KURRI) has been partially completed and is still in progress under the Joint Study Program with Argonne National Laboratory (ANL).

The JRR-3M commenced using LEU silicide fuel elements instead of LEU aluminide fuel elements in September, 1999.

The Japanese Government approved a cancellation of the KUHFR Project in February 1991, and April 1994 the U.S. Government gave an approval to utilize HEU fuel in the KUR instead of the KUHFR. Therefore, the KUR will be operated with HEU fuel until March 2004, then the full core conversion with LEU silicide will be done. The first shipment of spent fuels since 1974 was done in August, 1999.

INTRODUCTION

Among nineteen research reactors and critical assemblies in operation in Japan (Table 1 and 2), those which are relevant to the RERTR program are the JRR-3M, JRR-4 and JMTR of JAERI and KUR of KURRI (Table 3). The High Temperature Engineering Test Reactor (HTTR), which uses LEU fuel, reached the first criticality in November 1998. The RERTR program in Japan has been pursued extensively under the direction of the Five Agency Committee on Highly Enriched Uranium, which consist of the Science and Technology Agency, the Ministry of Education, Science and Culture, the Ministry of Foreign Affairs, JAERI and KURRI, which is held every three months[1-16] (Table 4). It has played a remarkable role in deciding policies related to the program, and the 87th Committee was held in August 1999. Recently, reprocessing of spent fuel has been mainly discussed.

Table 2. Japanese Critical Assemblies in Operation

Name	Owner	Site	Type and enrichment			Max. Power	Start-up date
TCA	JAERI	Tokai	H_2O(tank)	UO_2 UO_2-PuO_2	2.6% 4%	200W	1962.8
NCA	Toshiba	Kawasaki	H_2O(tank)	UO_2	1-5%	200kW	1963.12
FCA	JAERI	Tokai	fast horizontally split	U U Pu	93% 20%	2kW	1967.4
DCA	JNC	Oarai	D_2O(tank)	UO_2 UO_2-PuO_2	1.2% 1.5%	1kW	1969.12
KUCA	KURRI	Kumatori	various multi-core	U-Al UAl_x	93% 45%	100W 1kW (short time)	1974.8 1981.5
VHTRC	JAERI	Tokai	Graphite horizontally split	U	2,4,6%	10W	1985.5
STACY	JAERI	Tokai	Homogeneous Heterogeneous Tank type	U Pu	4,6,10%	200W	1995.2
TRACY	JAERI	Tokai	Homogeneous Tank type	U	10%	10kW $5x10^9$W (transient)	1995.12

Table 3. Research Reactor Relevant to RERTR in Japan

Name	Power(MW)	First Critical	Fuel Enrichment	Conversion
KUR(KURRI)	5	1964	HEU-LEU	2004
KUHFR(KURRI)	30	canceled		
JRR-3M(JAERI)	20	1962	LEU-LEU	1990
JRR-4(JAERI)	3.5	1965	HEU-LEU	1998
JMTR(JAERI)	50	1968	MEU-LEU	1994
Related Critical Assembly				
KUCA(KURRI)	0.0001	1974	HEU-MEU	1981

Table 4. History of Reduced Enrichment Program for Research and Test Reactors in Japan

1977.11	Japanese Committee on INFCE WC-8 was started.
1977.11	Joint Study Program was proposed at the time of the application of export license of HEU for the KUHFR.
1978.5	ANL-KURRI Joint Study Phase A was started.
1978.6	Five Agency Committee on Highly Enriched Uranium was organized.
1978.9	ANL-KURRI Joint Study Phase A was completed.
1979.5	Project team for RERTR was formed in JAERI.
1979.7	ANL-KURRI Joint Study Phase B was started.
1980.1	ANL-JAERI Joint Study Phase A was started.
1980.8	ANL-JAERI Joint Study Phase A was completed.
1980.9	ANL-JAERI Joint Study Phase B was started.
1981.5	MEU UAl_x-Al full core experiment was started in the KUCA.
1983.3	ANL-KURRI Phase B was completed.
1983.8	MEU UAl_x-Al full core experiment in the JMTRC was started.
1983.11	ANL-KURRI Phase C was started.
1984.3	ANL-JAERI Phase B was completed.
1984.4	ANL-JAERI Phase C was started.
1984.4	MEU-HEU mixed core experiment in the KUCA was started.
1984.9	Irradiation of 2 MEU and 1 LEU UAl_x-Al full size elements in the JRR-2 was started.
1984.10	Irradiation of LEU UAl_x-Al full size elements in the JRR-4 was started.
1984.11	Thermal-hydraulic calculations for the KUR core conversion from HEU to LEU was performed.
1985.1	Irradiation of MEU UAl_x-Al full size elements in the JMTR was started.
1985.3	Irradiation of MEU UAl_x-Al full size elements in the JMTR was completed.
	Irradiation of LEU U_xSi_y-Al miniplates in the JMTR was started.
1985.6	Irradiation of LEU U_xSi_y-Al miniplates in the JMTR was completed.
1985.10	Neutronics calculations for the KUR core conversion from HEU to LEU was performed.
1986.1	Irradiation of MEU UAl_x-Al full size elements in the JRR-2 was started.
1986.5	Irradiation of MEU UAl_x-Al full size elements in the JRR-2 was completed.
1986.8	The JMTR was fully converted from HEU to MEU fuels.

1987.11	MEU UAl_x-Al full core in the JRR-2 was started.
1988.7	PIE of MEU, LEU UAl_x-Al full size elements in the JRR-2 was completed.
1988.12	Irradiation of LEU UAl_x-Al full size elements in the JRR-4 was completed.
1990.3	LEU UAl_x-Al full core test in the new JRR-3 (JRR-3M) was started.
1990.11	Full Power operation of 20MW in the JRR-3M was started.
1992.5	Two LEU U_3Si_2-Al elements were inserted into the KUR core.
1993.11	Two LEU U_3Si_2-Al elements were inserted into the JMTR core.
1994.1	The JMTR was fully converted from MEU to LEU with U_3Si_2-Al fuel.
1994.9	ANL-JAERI Phase C was completed.
1995.12	The JMTRC was shutdown.
1996.12	The JRR-2 was shutdown.
1998.7	The JRR-4 was fully converted from HEU to LEU with U_3Si_2-Al fuel.
1999.9	The JRR-3M was fully converted from LEU UAl_x-Al fuel to LEU U_3Si_2-Al fuel.

JAERI

JRR-3M

The JRR-3M achieved its first criticality in March 1990 using LEU aluminide fuel (2.2gU/cm^3). Since November 1990, the JRR-3M has been operated for capsule irradiation, beam experiments and so on at the reactor power of 20MW. One operational cycle consists of four weeks of full power operation and one week of shutdown for refueling, irradiation capsule handling and maintenance.

The JRR-3M was fully converted to LEU silicide fuel (4.8gU/cm^3) with cadmium wires of burnable absober in September 1999 so as to decrease the number of spent fuels generated in a year.

JRR-4

The JRR-4 achieved the first criticality in July 1998 using LEU silicide fuel (3.8gU/cm^3) and commenced operation for medical irradiation and so on.

JMTR

The Japan Materials Testing Reactor (JMTR) was completely converted to the LEU fuel in January 1994. The LEU fuel is a silicide fuel(U_3Si_2) with 4.8gU/cm^3, and burnable absorber of cadmium wires is placed in each side plate of fuel element. The silicide fuel allowed an extension of JMTR operating days without refueling that has been taken a 26-day operation from a 12-day operation by high enrichnent uranium fuel core.

After the conversion, 334 LEU fuel elements have been used in JMTR without any trouble until August 1999.

Spent Fuel Management

Spent fuels from JRR-2, JRR-3M, JRR-4, JMTR and JMTRC are stored in their storage facilities. They will be shipped to U.S.A under the U.S. spent fuel acceptance policy of foreign research reactors. Three shipments of JAERI have been successfully completed since 1997.

KURRI

The Kyoto University Research Reactor (KUR, 5MW) has been operated since 1964 using HEU fuel. The KUR has been still utilized for boron neutron capture therapy. Since February 1990, 61 patients of cancer were treated by nine chief medical doctors of five groups. In order to increase the number of patients, the upgrade of the KUR Heavy Water Facility was completed. The main improvement of facility is (1) to realize an epithermal neutron field in addition to thermal neutrons, and (2) to irradiate patients during continuous operation of the KUR, which were licensed in June 1998.

According to the government policy, Kyoto University tried to convert the KUR to use the LEU fuel, and already two LEU silicide fuel elements have been inserted to the core in May 1992. The KUR will be operate with HEU fuel until March 2004.

As to spent fuel, the first shipment was done in August, 1999.

TRIGA FUEL

The Rikkyo University TRIGA II reactor will be shut down, and its spent fuel be return to US. In June 1998, Rikkyo University made a contact to fabricate a cask similar to the JMTR and the KUR fuels. Shipment will be done in Fiscal 2000.

Musashi Institute of Technology also has a TRIGA II reactor. No decision related its spent fuel has be done yet.

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Table 1. Japanese Research Reactors in Operation

Name	Owner	Site	Type and enrichment			Max. Power	Start-up date
UTR KINKI	Kinki University	Higashi-osaka	H_2O(UTR)	U-Al	90%	1W	1961.11
TRIGA-II RIKKYO	Rikkyo University	Yokosuka	H_2O(TRIGA)	U-ZrH	20%	100kW	1961.12
TTR-1	Toshiba	Kawasaki	H_2O(pool)	U-Al	20%	100kW	1962.3
JRR-3M	JAERI	Tokai	D_2O(tank)	U	Natural	10MW	1963.9
			H_2O(pool)	UO_2	1.5%	10MW	1972.1
				UAl_x-Al	20%	20MW	1990.3
				U_3Si_2-Al	20%	20MW	1999.9
MuITR	Musashi Inst. Tech.	Kawasaki	H_2O(TRIGA)	U-ZrH	20%	100kW	1962.3
KUR	KURRI	Kumatori	H_2O(tank)	U-Al	93%	5MW	1964.6
				U_3Si_2-Al	20%	5MW	1991.4
JRR-4	JAERI	Tokai	H_2O(pool)	UAl	93%	3.5MW	1965.1
				U_3Si_2-Al	20%	3.5MW	1998.7
JMTR	JAERI	Oarai	H_2O(MTR)	UAl	93%	50MW	1968.3
				UAl_x-Al	45%	50MW	1986.7
				U_3Si_2-Al	20%	50MW	1994.1
YAYOI	University Tokyo	Tokai	fast(horizontally movable)	U	93%	2kW	1971.4
NSRR	JAERI	Tokai	H_2O(TRIGA)	U-ZrH	20%	300kW	1975.6
HTTR	JAERI	Oarai	Graphite-He(gas)	UO_2 (particle)	9.9%(Max)	(30MW)	1998.11 (Critical)